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The Relationship of Personality and Behavior Change in a Physical Activity Intervention: The Role of Conscientiousness and Healthy Neuroticism

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Abstract

This study examined the role of personality traits in a 5-week physical activity intervention study for working adults. We tested whether personality traits predicted individual differences in change in daily steps over time. Fifty-two participants ages 35 to 69 ($M_{\text{age}} = 49.71$, $SD = 8.64$) wore a Fitbit Zip step counter for 35 days and completed a personality questionnaire. Participants were randomly assigned to either an implementation intention group or a control group. Both groups wore a Fitbit and had the goal to increase their daily steps. For the present study, the sample was collapsed across groups. Higher conscientiousness was associated with greater increases in daily steps. Also, individuals with *healthy neuroticism*, the combination of higher neuroticism and higher conscientiousness, showed greater increases in daily steps. The findings highlight that the efficacy of physical activity interventions may depend on personality traits. Intervention outcomes may be improved if personality is taken into account when designing the programs.

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Keywords

Physical activity intervention; personality traits; healthy neuroticism

Despite the fact that regular exercise has tremendous benefits for one's health and well-being (WHO, 2018), less than a quarter of US adults reach the nationally recommended amount of regular exercise (Clarke, Norris, & Schiller, 2017). There is compelling evidence that inactivity is associated with a range of severe, adverse health outcomes (Lee et al., 2012). In turn, an active lifestyle has broad and substantial benefits not only for physical health, but also for cognitive and psychological outcomes (Kohl et al., 2012). In recent years, interventions that target an increase in physical activity have been seen as one of the most promising non-pharmacological, non-invasive, and cost-effective methods to promote public health (Lachman et al., 2018; WHO, 2018). In order to optimize the effectiveness of such interventions, factors that contribute to an individual's inactive lifestyle and receptiveness to change need to be taken into account. These factors not only include an individual's health status or the social and environmental context, but also psychological factors such as personality traits (Bauman et al., 2012).

Personality traits constitute a significant psychological component predicting health maintenance behaviors, long-term health outcomes, and even mortality (Chapman, Roberts, & Duberstein, 2011; Mroczek & Spiro, 2007). As such, the effectiveness of health behavior change interventions may critically depend on personality disposition (Chapman, Hampson, & Clarkin, 2014). However, it is unclear whether personality traits predict an individual's success in increasing daily steps when enrolled in a physical activity intervention. The goal of this study was to test whether personality traits predicted the extent to which study participants were able to increase their daily steps over time.

Personality and Health Behavior

Personality traits are associated with engagement in or abstinence from health behaviors that ultimately impact health across the lifespan (Friedman, 2000). Although all Big Five traits have been linked with health behaviors and outcomes (Hampson & Friedman, 2008), the strongest links have been found for conscientiousness and neuroticism (Hampson, 2012). Lower conscientiousness and higher neuroticism have each been linked to negative health behaviors such as sedentary behavior, smoking tobacco, alcohol use, drug use, and unhealthy eating habits (Allen, Walter, & McDermott, 2017; Bogg & Roberts, 2004; Mroczek, Spiro, & Turiano, 2009). Similarly, research suggests that high conscientiousness and low neuroticism are related to positive health behaviors; two recent meta-analyses found that higher conscientiousness and lower neuroticism were associated with more physical activity (Sutin et al., 2016; Wilson & Dishman, 2015).

Personality and Behavior Change in Interventions

Most previous research that has investigated the role of personality in behavior change interventions has focused on adherence to medication and doctor's regimens. These studies suggested that higher conscientiousness was associated with greater doctor and medication

adherence (Christensen & Smith, 1995; Hill & Roberts, 2011). In terms of neuroticism, previous research found that high neuroticism was associated with lower medication adherence (Wheeler, Wagaman, & McCord, 2012). Potgieter and Venter (1995) also found that high neuroticism was linked to lower adherence to on-campus exercise over one year.

Despite the common assumption that higher neuroticism is related to worse health behaviors and outcomes, some researchers argue that high neuroticism can, under certain circumstances, also be positively related to health (Friedman, 2000). This concept received attention under the term *healthy neuroticism* and suggests that increased neuroticism could lead to vigilance (Weston & Jackson, 2018) and concern about poor health conditions and may potentially be beneficial. The aforementioned healthy form of neuroticism may arise when high neuroticism is combined with high conscientiousness. While neurotic individuals are likely to be concerned about their health, conscientious individuals tend to actively do something about these concerns by changing their health behaviors (Bogg, 2008). Healthy neurotics may be better able to channel their health concerns into positive behaviors such as sticking to a physical activity routine. A few studies suggest that *healthy neuroticism* is beneficial for health outcomes. Research suggests that healthy neurotics smoke fewer cigarettes and drink less alcohol (Vollrath & Torgersen, 2002) and are less likely to smoke after the onset of several diseases (Weston & Jackson, 2015). However, past investigations on the relationship between personality traits and health behaviors have been limited to observational studies and have yet to explore the role of personality traits in the context of behavior change interventions.

The Present Study

A preregistration of the study is available on the Open Science Framework (OSF; <https://osf.io/kngtq/>).

The goal of this research was to examine whether personality traits predicted the extent to which people increased their number of daily steps over 35 days. We preregistered the hypothesis that people with higher levels of conscientiousness and lower levels of neuroticism would show greater increases in daily steps. In addition, we explored whether *healthy neuroticism* predicted change in daily steps over time. We expected that healthy neurotics would show greater changes in daily steps as compared to people with lower levels in one or both of these personality traits.

Method

The study was approved by the University's Institutional Review Board. This study constitutes a secondary analysis of a physical activity intervention study (Robinson et al., 2019).

Participants

Fifty-two participants completed the personality assessment at the beginning of the study. Participants ranged in age between 35 to 69 ($M = 49.71$, $SD = 8.64$) with 71.2% females. The mean level of educational attainment was 15.92 years ($SD = 2.15$). The original

intervention study included two conditions and examined group differences in physical activity changes. In the present study, the focus was on individual differences in change across groups. Thus, the sample was collapsed across groups. The two groups did not differ in key variables of the study (i.e., personality traits, education, gender or functional health) except for age; the implementation intention group was significantly younger ($M = 46.79$, $SD = 8.09$) than the Fitbit control group ($M = 52.45$, $SD = 7.82$). Longitudinal multilevel modeling (Bolger & Laurenceau, 2013) included all possible observations over time (52 participants * 35 days = 1,820) and condition was added as a covariate.

The posthoc power analysis for the within-person effects with an estimated effect size of $d = .20$, with 80% power at $p = .05$ and 35 repeated measures, suggested a sample size of at least 38 participants, thus the sample size of the present study provides enough power.

Procedure and Intervention

Participants were recruited via flyers, community events, and online advertisements in the greater Boston-area, Massachusetts, United States. Flyers advertised that the study was for people who did not have enough time to exercise and were interested in becoming more active in their daily life using a step counter. Interested participants were eligible for the intervention study if they were inactive (less than CDC recommendations of 150 min of moderate or vigorous activity per week), healthy, working at least 35 hours a week, between 35 and 69 years of age, and had access to a computer and/or a smartphone or tablet.

Participants were asked to wear a Fitbit Zip each day over 5 weeks to track their daily steps. Participants were randomly assigned to either an implementation intention group or a Fitbit control group. Both the implementation intention and the Fitbit control group received daily emails recommending that they increase their steps by 2,000 each week, according to recommended guidelines (e.g., Hill, Wyatt, Reed, & Peters, 2003), and asking them to record their steps and answer a few questions about their daily experiences. The only difference between groups was that those in the implementation intention group were instructed on how to build implementation intentions (how to plan how, where, and when they would add steps to their daily routine).

All participants monitored their steps using a Fitbit Zip over five weeks and were instructed to wear the Fitbit each day from when they woke up to when they went to bed. The first week was a baseline week to track daily steps without sending daily e-mails, followed by four weeks of daily e-mails with either instructions on how to form implementation intentions and daily assessments (implementation intention group) or daily assessments alone (Fitbit control group). As compensation, participants could either keep the Fitbit or opt to receive comparable monetary compensation.

Measures

Personality traits—The Big Five personality traits were assessed at the beginning of the study using the Midlife Development Inventory (MIDI; Lachman & Weaver, 1997). Participants were asked how much 25 adjectives that assessed neuroticism, conscientiousness, extraversion, openness, and agreeableness described themselves on a

scale ranging from 1 (not at all) to 4 (a lot). Cronbach's alphas were .77 for conscientiousness, .74 for neuroticism, .78 for openness to experience, .78 for extraversion, and .77 for agreeableness.

Physical activity—Physical activity was operationalized with daily steps. Daily steps were measured with the Fitbit Zip wireless activity tracker. Participants were asked to synchronize their Fitbit via Bluetooth to their computer and/or smartphone or tablet each day. Daily estimated activity data were aggregated via the Fitabase API platform. Daily steps were counted for each day the person wore the Fitbit for at least eight hours. Adherence to wearing the Fitbit Zip was high and stable, with $M = 31.88$ valid days out of 35 days ($SD = 4.76$) across participants, which is 91.09 %.

Analytical Strategy

We used longitudinal multilevel modeling (MLM; Bolger & Laurenceau, 2013) and the lme4 package (Bates et al., 2011) in R (R Core Team, 2019) to examine whether personality traits predicted change in daily steps over time. We examined the hierarchical structure of the data by computing intraclass correlation coefficients (ICC) and investigated the within- person variation of daily steps. Results showed that 39 % of the total variance of daily steps were within-person (plus residual variance), which justified the use of multilevel modeling. Time was coded linearly as $0 = \text{Day 1}$ to $34 = \text{Day 35}$. Age, gender, education, functional health, and condition (implementation intention group vs. Fitbit control group) were included as control variables. The models were estimated with maximum likelihood (ML). Independent variables and control variables were grand mean centered. To explore whether the effects differed across the two conditions, we also tested the interaction with condition and tested the same models with split samples by condition. In these additional analyses, the interaction effects with condition were not significant and we found similar effects in both groups using split samples. As we did not find differences between conditions, we focused on the combined data in reporting the results. We used the interactions package (Long, 2019) with the functions “interact_plot” and “sim_slopes” in R (R Core Team, 2019) to probe interaction effects using the Johnson Neyman Technique (Preacher, Rucker, & Hayes, 2007) to show where the relationship between the independent variable and the outcome variable is statistically significant (Preacher, Rucker, & Hayes, 2007).

Datasets and R-Codes are available on the Open Science Framework (OSF; <https://osf.io/kngtq/>).

Results

Do Personality Traits Predict Change in Daily Steps?

Means and standard deviations for all variables are in Table 1. Table 2 depicts the results of conscientiousness and neuroticism predicting change in daily steps over time. Supplementary Table 1 shows the non-significant effects of the other Big Five personality traits (extraversion, agreeableness, and openness) on change in daily steps. Conscientiousness at pretest positively predicted change in daily steps over time. Figure 1 depicts the effect of conscientiousness predicting change in daily steps over time.

Participants with +1 *SD* in conscientiousness showed greater increases in daily steps over time compared to people with mean level conscientiousness or people with –1 *SD* conscientiousness. To examine the region of significance, we used the Johnson-Neyman (J-N) technique. The results of the J-N technique analyses suggest the region of significance for change in daily steps was when an individual's score in conscientiousness was outside the interval [–3.55, 0.01]. In other words, if participants' grand-mean centered conscientiousness was greater than 0.01, they were more likely to increase their daily steps compared to participants with conscientiousness below 0.01.

To examine if healthy neuroticism predicted change in daily steps, we examined whether an interaction of conscientiousness, neuroticism, and time predicted change in daily steps. Table 2 shows the results of this three-way interaction and Figure 2 depicts the direction of this interaction. The results suggest that people with lower levels in neuroticism (–1 *SD*) and lower levels in conscientiousness (–1 *SD*) benefited the least from taking part in the physical activity intervention. However, consistent with predictions, participants with higher levels in neuroticism (+1 *SD*) and higher levels in conscientiousness (+1 *SD*) were particularly successful in increasing their daily steps over time. Again, we used the J-N technique to test the region of significance of this interaction. When grand-mean centered neuroticism was added as a second moderator and held constant at +1 *SD* = 0.62, conscientiousness was significant outside the interval [–2.53, 0.15]. In other words, participants who had higher neuroticism (+1 *SD*) and conscientiousness scores above –0.15 increased significantly more in daily steps compared to participants, who had higher neuroticism (+1 *SD*) but conscientiousness scores below –0.15. Note that other interactions between Big Five personality traits did not predict change in daily steps over time.

Discussion

The current study examined the extent to which personality traits predicted success in increasing daily steps when enrolled in a physical activity intervention. We found that conscientiousness significantly predicted change in daily steps. In addition, participants with higher neuroticism – when paired with higher conscientiousness – showed greater increases in daily steps compared to participants with lower levels in one or both of these two personality traits.

While there exists a large body of literature examining how personality impacts health behaviors and health, few studies have examined the role of personality in the context of behavior change interventions. In the present study, we found that higher conscientiousness predicted a greater increase in steps over time, which is in line with previous research that showed that planfulness – an aspect of conscientiousness – predicted exercise goal achievement (Ludwig, Srivastava, & Berkman, 2019). No significant effects were found for agreeableness, extraversion, or openness, which is in line with our expectations as well as prior studies in which these personality traits were not related to people's adherence to medication and doctor's regimens (e.g., Christensen & Smith, 1995; Wheeler et al., 2012). As such, the present findings put conscientiousness in center stage for possible personalization of physical activity interventions. For instance, it may be that individuals lower in conscientiousness may need an enriched intervention that also targets an increase in

conscientiousness. Indeed, recent work suggests that traits such as conscientiousness may be changeable with the help of targeted interventions (Stieger et al., 2020).

The present findings also provide evidence for the adaptive value of “healthy neuroticism” suggesting that higher levels of neuroticism may be beneficial when promoting health behaviors as long as they are accompanied by high conscientiousness. Theoretically, healthy neurotics experience increased health related anxiety (Guthold et al., 2018), but they are also successful in channeling their anxiety towards making beneficial health choices due to their increased conscientiousness (Hill & Roberts, 2011). So far, the beneficial effects of healthy neuroticism have mainly been found in observational studies (e.g., Turiano et al., 2013). The present study is the first to provide evidence that healthy neurotics may also be better able to improve their health behaviors in the context of a behavior change intervention.

Strengths, Limitations, and Future Directions

Overall, the present results extend previous literature by suggesting that personality measurements may potentially be useful to identify those at risk of poorer outcomes in the context of a health behavior change intervention. The findings support the value of considering personality when personalizing interventions and also reinforce recent calls to personalize behavior change interventions towards the needs of participants rather than a one-size-fits-all solution (Chapman et al., 2014; Robinson & Lachman, 2016). Personality measures may function as an inexpensive and accessible tool to personalize behavior change interventions (Chapman et al., 2014). The goal of personalized interventions is to enhance motivation, increase the efficacy of the intervention, and potentially reduce the overall burden of health care costs (Israel et al., 2014; Lachman et al., 2018) by increasing the fit between individuals and type of intervention.

The present research also has some limitations that can inform future research. First, based on the present study, it is unclear whether the findings also will generalize to other populations as the study was conducted with a sample of healthy working adults in the US ages 35 to 69. Second, as this is the first study to provide evidence that healthy neurotics may be better able to change their health behaviors in the context of an intervention, it is unclear if this only occurs under certain circumstances. For instance, it may be that the mere presence of a step counter and daily reminders triggered health concerns among healthy neurotics and thus channeled their behaviors towards healthier choices. Future studies are needed to better understand what contexts and behaviors may foster healthy neuroticism as well as to investigate the underlying mechanisms that drive healthy neurotics towards showing more health behaviors. Third, other moderating mechanisms may affect the link between personality traits and behavior change in a physical activity intervention which need to be examined more thoroughly in the future. For example, the type of one’s job may need attention as it may impact both personality traits as well as physical activity. Personality could also have an impact on job choice. Fourth, for the present study, the hip-worn Fitbit Zip was used to track participants’ physical activity. Previous research suggests considerable variability in accuracy across different physical activity monitors, placement sites (e.g., wrist or hip), speeds of activity, and conditions (e.g., free-living condition or treadmill) (e.g., An, Jones, Kang, Welk, & Lee, 2017). In general, hip-worn activity trackers

are suggested to outperform wrist-worn activity trackers in their accuracy especially at slower walking speeds (Diaz et al., 2015) and the Fitbit Zip was found to be one of the most accurate step count measures (An et al., 2017). However, future research is needed to test if other measures of physical activity reveal similar findings.

Conclusion

This study examined the role of personality traits in the context of a physical activity intervention. Our findings suggest that, regardless of their intervention condition, individuals with higher conscientiousness were better able to increase their daily steps. Also, people with *healthy neuroticism*, the combination of higher neuroticism and conscientiousness, showed greater increases in their daily steps over time. Overall, the results highlight that the efficacy of behavior change interventions may depend on individual differences and outcomes may be improved when personality is taken into account.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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M.S. wrote the manuscript and analyzed the data. S.R., A.B., and M.L. designed the study and collected the data. All authors gave feedback on earlier versions of the manuscript.

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Figure 1.
Conscientiousness Predicting Change in Daily Steps over Time

Figure 2.
Three-Way Interaction of Conscientiousness, Neuroticism, and Daily Steps over Time

Table 1.

Descriptive Statistics

Outcome	<i>M</i>	<i>SD</i>
Neuroticism	1.92	0.66
Conscientiousness	3.41	0.55
Extraversion	2.82	0.59
Openness	2.96	0.62
Agreeableness	3.31	0.61

Note. *N* = 52.

Table 2.

Personality Traits at Pretest Predicting Change in Daily Steps over Time

	Model with Conscientiousness				Model with Neuroticism				Model with Conscientiousness*Neuroticism			
	<i>B</i>	<i>SE</i>	<i>p</i>	<i>CI₉₅</i>	<i>B</i>	<i>SE</i>	<i>p</i>	<i>CI₉₅</i>	<i>B</i>	<i>SE</i>	<i>p</i>	<i>CI₉₅</i>
Intercept	6314.34	1785.45	< .001	2750.60; 9878.65	5850.41	1774.85	< .001	2307.29; 9392.60	6474.20	1813.38	< .001	2854.75; 10094.42
Time	16.00	8.42	0.058	-0.53; 32.52	16.92	8.42	0.045	0.41; 33.43	8.62	8.86	0.331	-8.75; 25.99
T1 Cons	345.34	795.86	0.666	-1237.82; 1927.09			-		-138.37	950.16	0.885	-2030.00; 1750.13
T1 Neuro			-		-641.87	608.55	0.295	-1851.17; 566.70	-590.47	746.49	0.432	-2075.25; 892.39
Age	28.43	45.99	0.539	-63.39; 120.27	41.17	45.82	0.373	-50.31; 132.65	28.86	46.90	0.541	-64.78; 122.50
Gender	-1666.88	784.87	0.038	-3233.54; -99.36	-1420.42	782.41	0.075	-2981.71; 142.31	-1666.36	811.31	0.045	-3285.39; -45.79
Condition	2201.63	746.69	0.005	710.37; 3691.84	2226.39	755.13	0.005	718.37; 3733.49	2164.99	755.01	0.006	656.84; 3671.57
Education (years)	-100.07	163.98	0.544	-427.38; 227.33	-63.40	166.21	0.704	-395.08; 268.52	-108.43	171.49	0.530	-450.79; 233.97
General health	-12.07	19.65	0.542	-51.30; 27.16	-5.26	19.08	0.784	-43.35; 32.81	-11.93	20.26	0.558	-52.36; 28.52
T1 Cons*Time	36.81	16.14	0.023	5.14; 68.47			-		71.16	18.66	< .001	34.55; 107.76
T1 Neuro*Time			-		21.22	13.50	0.116	-5.25; 47.70	37.50	15.86	0.018	6.40; 68.60
T1 Cons*T1 Neuro			-				-		509.59	745.91	0.497	-971.06; 1991.44
T1 Cons*T1 Neuro*Time			-				-		-37.49	17.68	0.034	-72.15; -2.82
AIC			31805.9				31810.0				31800.2	
BIC			31865.4				31869.5				31881.4	
Log likelihood			-15891.9				-15894.0				-15885.1	
<i>R</i> ² conditional			0.395				0.392				0.400	

Note. Number of observations = 1658; DV = daily steps; predictors are grand-mean centered; cons = conscientiousness; neuro = neuroticism; AIC = Akaike information criterion; BIC = Bayesian information criterion; Fit indices of null model: AIC = 36226.9, BIC = 36249.1, Log likelihood = -18109.4.